CONFIDENTIAL

Third Bimonthly Report

on the

Miniature IF Amplifier Program

Period: 1-Nov.-1959 to 1-Jan.-1960

[redacted] 25X1

Prepared by: [redacted] 25X1

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I. Purpose

See Bimonthly Report No. 1.

II. Abstract

Fabrication of the crystal filter for use in the IF amplifier to be designed for operation in a single conversion receiver has been essentially completed. It was originally anticipated that work on this filter would be finished by December 31st, 1959. However, some last minute difficulties arose which have delayed delivery of the filter to [redacted] 25X1
by a few weeks. A description of the crystal filter work is included in this report. 25X1

The amplifier for use in a double conversion receiver utilizes, in the low IF amplifier, ceramic transformers for interstage coupling and selectivity. During previous reporting periods a number of ceramic transformers have been evaluated for bandwidth, insertion loss and temperature stability. When a suitable design had been determined a number of similar units was fabricated and during the past two months the performance of these ceramic transformers has been evaluated in a breadboard version of the complete low IF amplifier. Response curves and circuit diagrams are included in this report.

III. Factual Data

(a) Ceramic Resonator Program

The characteristics of two different groups of ceramic transformers have been evaluated. Four different circuits were used in the evaluation.

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The two passive circuits, shown in Figures 1 and 2 were used to determine the frequency response of the individual transformers. Figure 3 shows a three-stage amplifier, the overall gain-bandwidth characteristics of which have been studied. Figure 4 shows essentially the same circuit with the addition of another transistor to increase the overall sensitivity. The circuits shown in Figures 1 and 2 were used in order to obtain the data given in Tables 1 and 2 respectively.

Sample	f_R	f_L	f_H	BW
PZT No. 7	457.9	455.0	460.9	5.9
No. 2	450.7	445.3	454.3	9.0
No. 5	456.1	451.7	458.8	7.1
No. 6	451.7	447.3	455.6	8.3
ANA No. 1	452.7	445.2	458.4	13.2
No. 3	451.3	444.1	457.2	13.1
No. 6	459.2	451.0	465.0	14.0
No. 7	457.9	450.4	464.5	14.1

TABLE 1

Sample	f_R	f_L	f_H	BW
ANA No. 1	454.7	445.1	462.3	17.3
No. 3	456.1	441.4	465.6	24.2
No. 6	460.8	447.9	469.2	21.3
No. 7	461.0	420.8	478.4	57.6
PZT No. 2	454.2	442.6	461.6	19.0
No. 5	456.6	451.9	462.3	10.4
No. 6	454.3	447.1	459.5	12.4
No. 7	461.0	452.3	465.1	12.8

TABLE 2

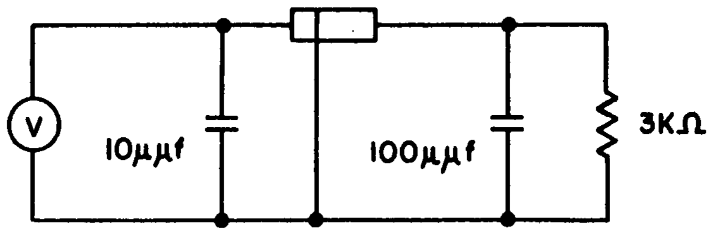


FIGURE 1

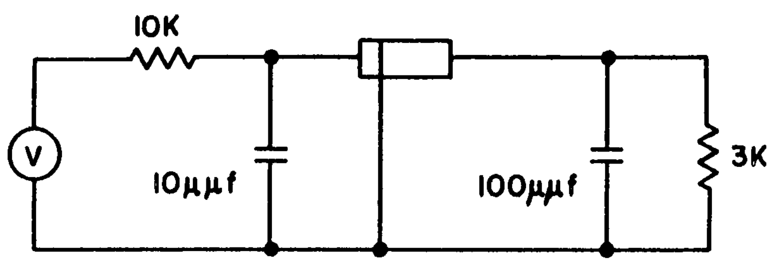
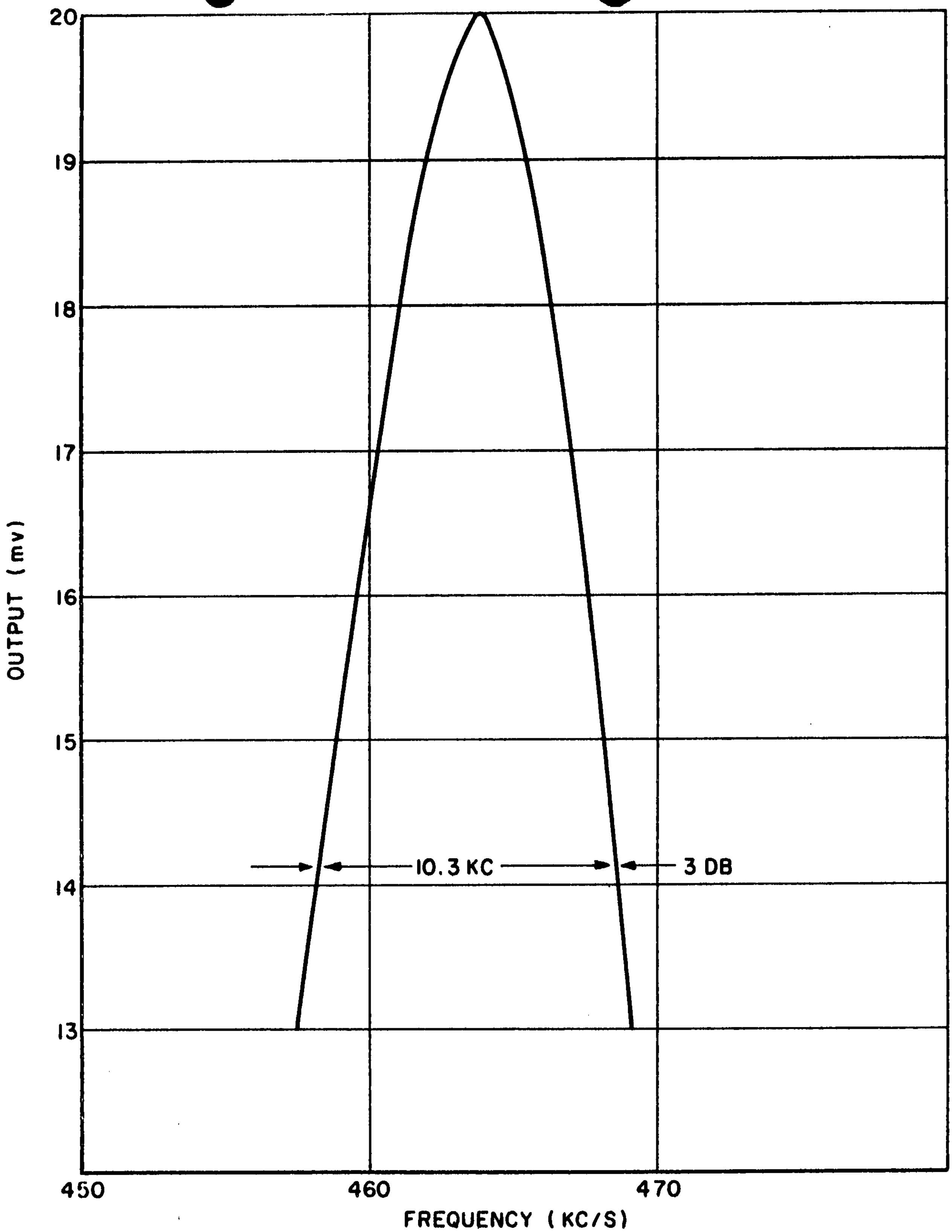
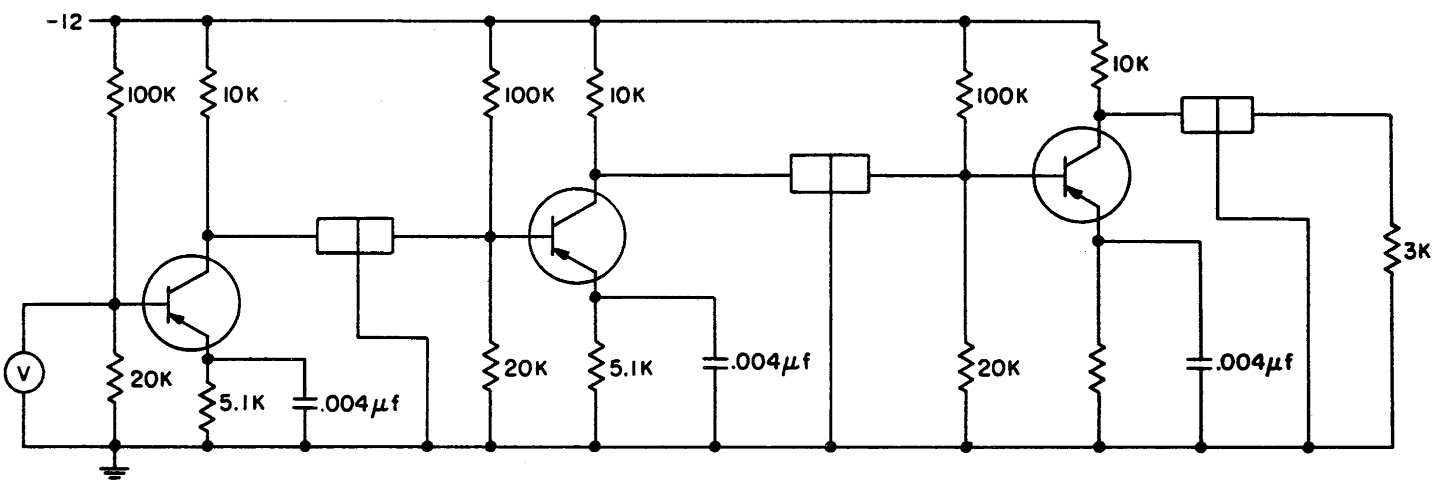


FIGURE 2



OUTPUT VOLTAGE VS FREQUENCY USING 2 STAGE AMPLIFIER WITH CERAMIC TRANSFORMER COUPLING

FIGURE 3



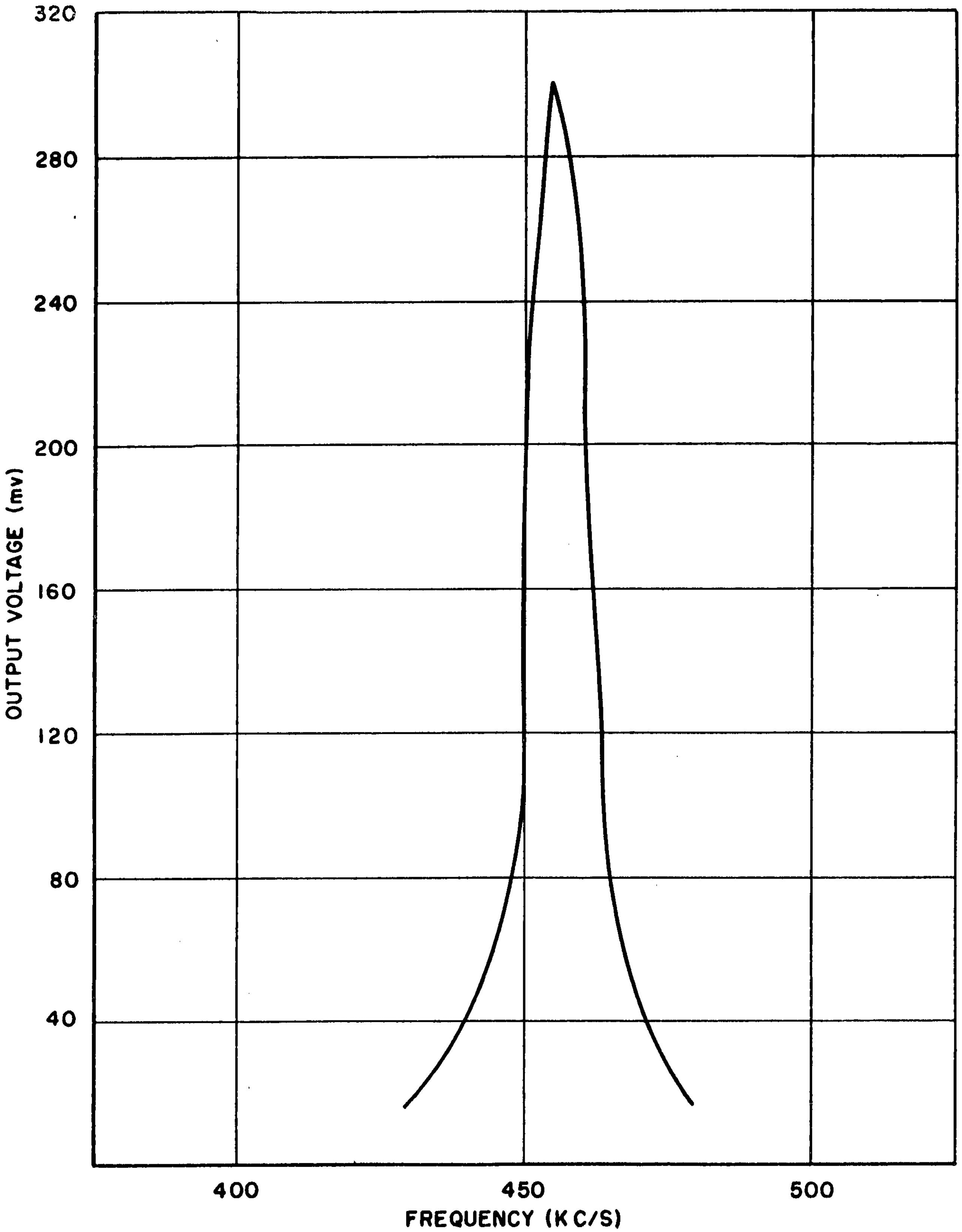
TRANSISTORS 2N274
TRANSFORMER SEQUENCE ANA #1 ; ANA #6 ; ANA #7

FIGURE 4

2C

It should be noted that the results obtained from the two test circuits are, in all cases, different. While undoubtedly some of the discrepancies may be attributed to experimental error, in general they serve to indicate the significance of the terminating impedances of the ceramic transformer. The circuit of Figure 1 probably gives a truer picture of the actual resonant frequency and bandwidth associated with the individual resonators. On the other hand the circuit of Figure 2 more closely simulates the conditions which would be prevailing in an actual amplifier stage. From an overall circuit performance standpoint the data given in Table 2 is, consequently, the more significant.

The frequency response characteristic shown in Figure 3 was obtained using a two-stage ceramic coupled amplifier. The circuit of Figure 4 was used to determine the overall gain-bandwidth characteristics of a three-stage amplifier. In the original proposal it was anticipated that it would be necessary to place a lumped ceramic filter between the output of the mixer and the input stage of the low IF amplifier in order to obtain adequate skirt selectivity. From the results obtained recently, the use of a lumped filter may not be justified. If a filter is not required an appreciable step can be taken in the reduction of the overall physical size of the complete amplifier. The frequency response of the three-stage amplifier is shown in Figure 5. As may be seen, the resonant frequency is 456 kc and the bandwidth, 8 kc. Using a constant voltage source at the input to this circuit, there was no discernable output at any frequency above 480 kc or below 420 kc. The readings, beyond these frequencies were limited by approximately 5 mv of 455 kc noise. The following calculation indicates that this is not an unreasonable noise level.



OUTPUT VOLTAGE VS FREQUENCY 3 STAGE AMPLIFIER USING CERAMIC TRANSFORMERS

FIGURE 5

Thermal Noise Power Available at Input = KTB

$$= 1.38 \times 10^{-23} \times 300 \times 10^{4}$$

$$= 0.41 \times 10^{-16} \text{ watts}$$

$$\text{Noise Power at Output} = \frac{(5 \times 10^{-3})^2}{3 \times 10^3} = 8.33 \times 10^{-9} \text{ watts}$$

Amplifier Gain = 75 db approx.

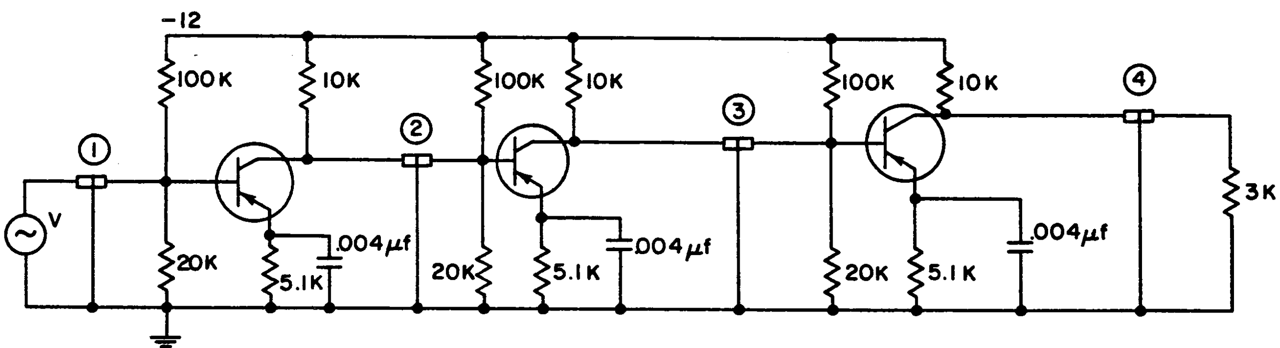
$$\text{Noise Figure} = \frac{8.33 \times 10^{-9}}{.41 \times 10^{-16} \times 10^{7} \times 3} = 6.67 \text{ i.e., 8 db approx.}$$

By subsequent adjustment of the operating point or selection of the input transistor it may be possible to improve on this figure somewhat.

As mentioned previously, the good skirt selectivity obtained with the ceramic transformers has opened up the possibility of omitting the lumped filter from the low IF amplifier. With this objective some tests have been made using the circuit of Figure 6. This arrangement is essentially the same as that of Figure 4 with the addition of a ceramic transformer at the input to increase the overall selectivity of the amplifier. The frequency response of this circuit is shown in Figure 7. As may be seen from the curve, the passband is appreciably narrower than those shown previously.

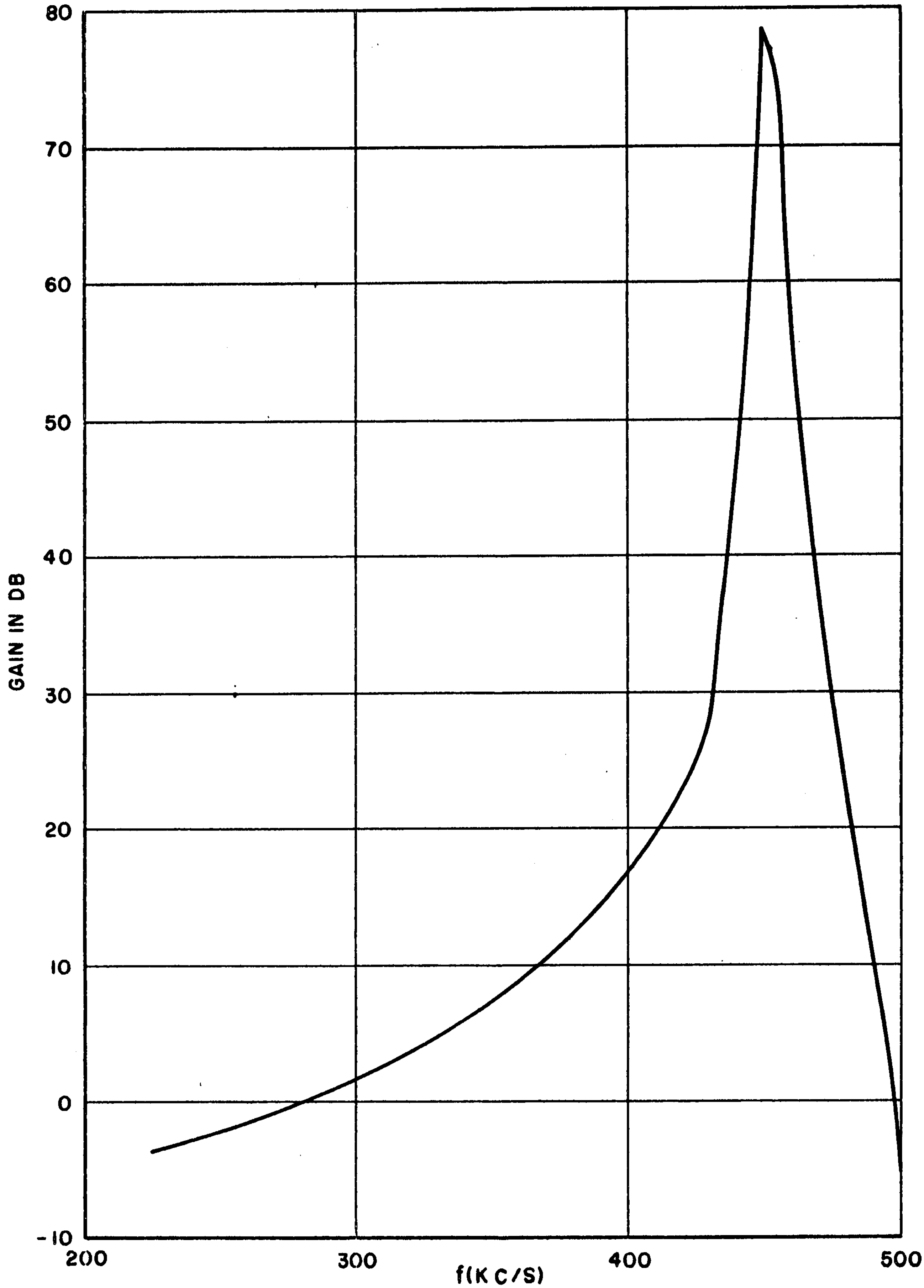
(b) Crystal Filter Program

The design of the crystal filter has been essentially completed. Variations in crystal capacity and resistance resulted in some changes of the terminating circuits. Performance of the filter in its original package measuring .75 x .75 x 1.75 inches did not meet the 60 db specification. The addition of some interior shielding and the use of higher quality



ALL TRANSISTOR 2N274
TRANSFORMER SEQUENCE PZT #2 ; ANA #1 ; ANA #6 ; ANA #7 .

FIGURE 6



POWER GAIN VS FREQUENCY

FIGURE 7

coil forms for the input circuit improved performance considerably but necessitated an increase in the physical size by approximately 0.35 cubic inches. Small coil forms would have reduced the volume but would have, of necessity, been of higher permeability with poorer temperature stability.

The capacity between the quartz crystal elements and the crystal cans was not identical for all crystals. This capacity causes an unbalance of the half lattice network. Grounding one or more of the crystal cans partially overcomes this effect.

The coils of the terminating circuits do not contribute to the filter performance except from the impedance matching point of view. The Q of the coils must be at least 250 to prevent undue loading of the filter. Even the best coils available loaded the filter slightly, but this could be compensated by an adjustment in the turns ratio of the transformer. The response of the complete filter is shown in Figure 8.

IV. Conclusions

Preliminary tests have indicated the possibility that adequate skirt selectivity can be obtained without the use of a lumped ceramic filter preceding the low IF amplifier. This would be highly desirable from considerations of overall size. Three stages of amplification in the low IF section provide a gain of approximatly 75 db. In addition to the good skirt selectivity obtained with the ceramic transformers adequate bandwidth is provided. The basic electrical design of the low IF section has been completed.

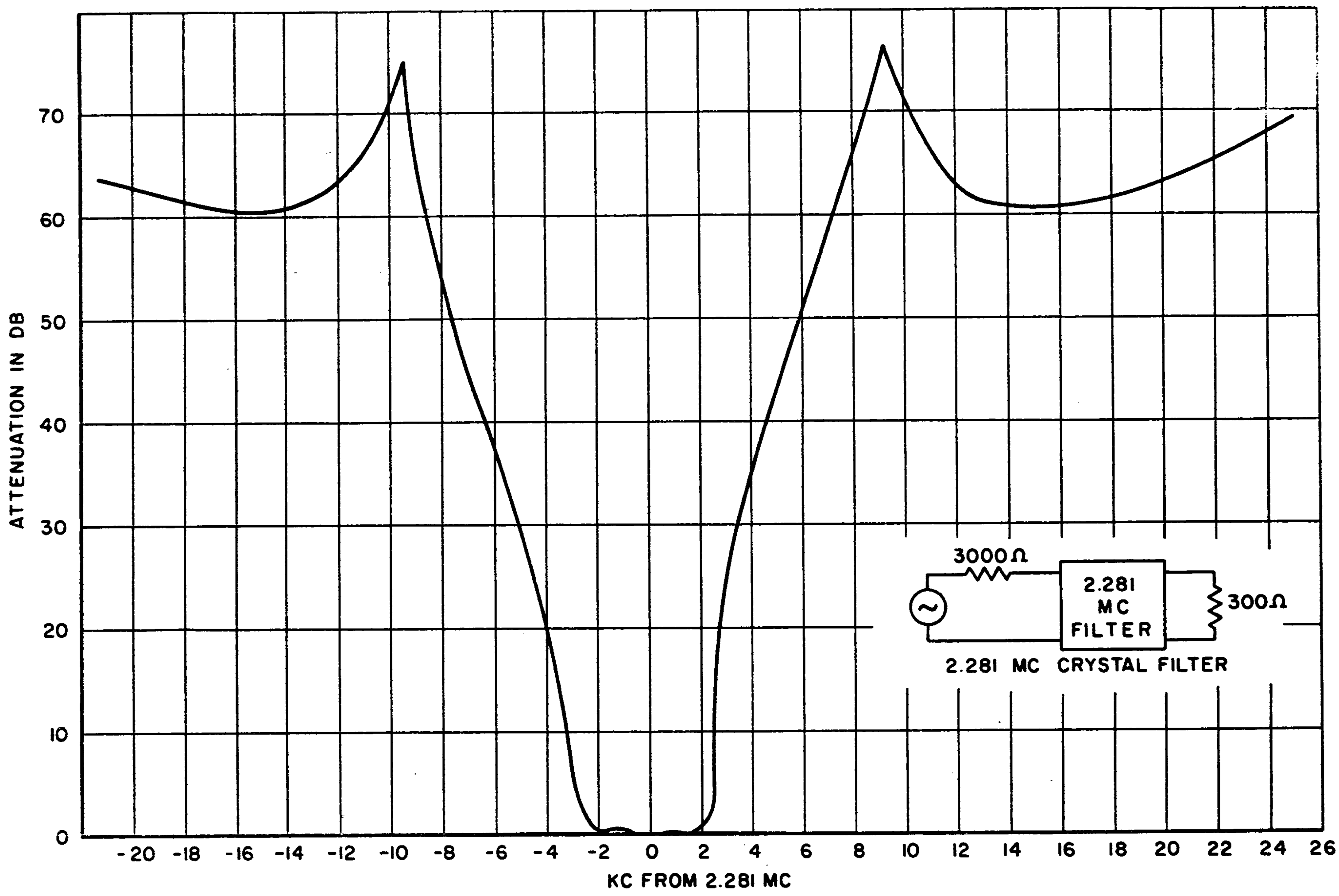


FIGURE 8

5A

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Successfull operation of the crystal filter has been obtained. It has been necessary to exceed the original volume estimate slightly. This has been due to the difficulty of obtaining sufficient rejection outside the pass band when input and output to the filter section are physically very close together rather than due to any inadequacy in the electrical design of the filter.

V. Future Plans

Having completed the basic electrical design of the low IF section it will be necessary to temperature test the amplifier to ensure that the bandwidth and center frequencies remain within tolerances over the -40 to +40°C range. Work has been started on the mixer and local oscillator stages as well as the high IF amplifier. This work will continue so that the performance of the entire unit can be tested in breadboard form before final packaging.

Delivery of the miniature crystal filter has been slightly delayed. As soon as it is received the 2.281 mc amplifier stages will be built up and evaluated in breadboard form. After any necessary modifications have been made, work will start on the final packaging of the single conversion IF amplifier.

VI. Identification of Key Technical Personnel

The following name should be added to those listed in previous reports.

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